Name: **Enrolment No:**	

UPES

End Semester Examination, May 2023

Course: Gas Dynamics and Jet Propulsion **Semester : VI**
Program: B. Tech Aerospace **Time : 03 hrs.**
Course Code: ASEG3022 **Max. Marks : 100**

Instructions: Make use of sketches/plots to elaborate your answer. Brief and to-the-point, answers are expected. Assume suitable data if needed. Gas Table allowed, Refer attached formula sheet.

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	State the technology challenges of future flight.	**4**	**CO1**
2	Discuss the losses involved in the ramjet and turbojet engines.	**4**	**C02**
3	Explain the condition of thermal choking in Rayleigh flow.	**4**	**C01**
4	Explain why most of the jet uses convergent nozzle whereas all the rocket uses a convergent divergent nozzle with suitable example.	**4**	**C03**
5	Discuss the Ideal cycle Ramjet engine through TS plot.	**4**	**C01**

SECTION B
(4Qx10M= 40 Marks)

6	Find the Mach numbers before and after the normal shock which occurs in the diverging section of a convergent-divergent air nozzle whose throat area is half of exit area and the ratio of stagnation pressure at entry is 2.5 times the exit static pressure . Also , find the location of the shock with respect to throat area.	**10**	**CO3**
7	Calculate equivalent fuel consumption ESFC of a turboprop engine that consumes 700 kg of fuel per hour and produces 320 kg of exhaust thrust and 3300 shaft horsepower (shp) during flight at 250 mph. The propeller efficiency is 0.9.	**10**	**C02**
8	Find the average friction factor between the two sections. In order to measure the friction coefficient in a supersonic flow of air in a constant area duct , a converging–diverging nozzle attached to the insulted duct is employed . Air from a reservoir is supplied to the nozzle . The pressure and temperature of air in the reservoir which supplies air to the nozzle are 6.73 MPa and 312 K . The nozzle throat is 6.1 mm, and the tube diameter is 12.7 mm . The pressure measured at 22.2 m and 375 . 9 mm from the duct intel are 0.238 MPa and 0.485 MPa respectively . Assuming the flow in the nozzle to be isentropic ,	**10**	**CO3**
9	Discuss the following parameters of a jet engine and state their effects on a performance of aircraft engine.	**10**	**C02**

1. Propulsive efficiency
2. Thrust specific fuel consumption
3. Thermal efficiency
4. Takeoff thrust

OR

Compute the thrust-specific fuel consumption of a Ram jet engine under the given condition.
Mach number= 2
Altitude =35,000 ft
Ta = - 63.7^0 C
Pa = 12.75 kPa
Maximum Temperature = 2300 K
Hydrocarbon fuel Qr = 45, 000 kJ/kg
Assume constant properties of Υ and Cp , all process are Ideal no aerodynamics losses , no pressure loss.

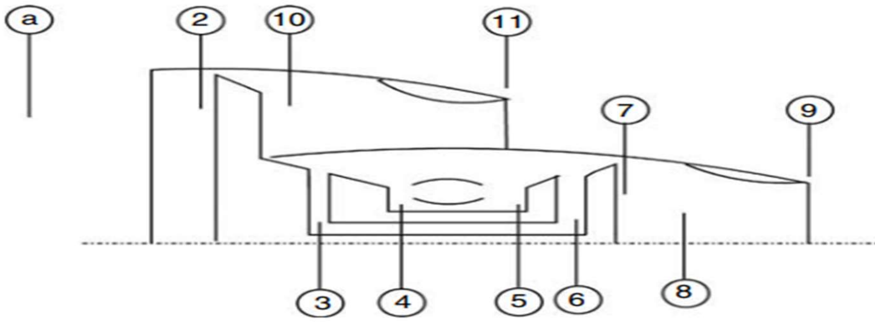
SECTION-C
(2Qx20M=40 Marks)

10 | Analyzed the two-spool turbofan engine . The low-pressure spool is composed of a turbine driving the fan and the LPC. The high-pressure spool is composed of a HPC and a HPT. Air is bled from an intermediate state in the HPC. The total pressure (in bar) and total temperature (in ◦C) during a ground test (M = 0.0) are recorded and shown in the following table

Station	Fan Inlet	Fan Outlet	LPC Outlet	Air bleed Location	HPC Outlet	CC outlet	HPT outlet	LPT outlet
Po	1	1.6	2.45	7.58	23.92	22.89	5.95	1.47
To	15	63	110	276	500	1300	910	520

The fan and turbine nozzles have isentropic efficiency of 0.9.
Burner efficiency = 0.96 QHV = 45,000 kJ/kg specific heat ratio for air = 1.4 specific heat ratio for gases = 1.33
Calculate the following:
(a) The fan isentropic efficiency (stations 2)
(b) The high-pressure ratio isentropic efficiency (stations 3–4)
(c) The fuel-to-air ratio (f)
d) The air bleed ratio (b)
(e) The BPR (β)
(f) The thrust force if the total air mass flow rate is 280 kg/s

20 | **C04,CO5**

			
11	A single spool afterburning turbojet engine is powering a fighter airplane flying at Mach Number Ma = 2 at an altitude of 16,200 m where the temperutre is 216.6 K and the pressure is 10. 01 kPa. The inlet is of axisymmetric type and is fitted with spike having a deflection angle 12^0 . The air mass flow rate is 15 kg/s . the compressor has a pressure ratio of 5 and isentropic efficiency of 0.85. the pressure loss in the combustion chamber is 6 % and the heating value of fuel is 45,000 kJ/ kg. the burner efficiency is 0.96 and turbine inlet temperature 1200 K and its isentropic efficiency is 0.9. the maximum temperature in the afterburner is 2000 K. the pressure drop in the afterburner is 3 % and the afterburner efficiency is 0.9 . the nozzle efficiency is 0.96 calculate. 1. The stagnation pressure ratio of the diffuser and its isentropic efficiency 2. The thrust force. **OR** Calculate the specific thrust and the TSFC of a single-spool turbojet engine having the following peculiarities: Cruise velocity of 280 m/s at altitude of 7000 m Intake efficiency of 93% Compressor pressure ratio of 8:1 and efficiency of 87% Burner efficiency of 98% Pressure drop in the combustion chamber of 4% of the delivery pressure of the compressor TIT of 1200 K and efficiency of 90% Mechanical efficiency of 99% Nozzle efficiency 95% Fuel heating value 44,000 kJ/kg	**20**	**CO4**

- fuel-to-air ratio $(f) = \frac{\dot{m}_f}{\dot{m}_a}$
- $T_{momentum} = \dot{m}_a(1+f)U_e$ $\quad T_{pressure} = (P_e - P_a)A_e$

  $T = \dot{m}_a[(1+f)U_e - u]$ or $T = \dot{m}_a[U_e - u]$

  $\therefore$ Thrust $= \dot{m}_a[(1+f)U_e - u] + (P_e - P_a)A_e$
- $T = \dot{m}_h[(1+f)U_{eh} - u] + \dot{m}_c(U_{ec} - u) + A_{eh}(P_{eh} - P_a) + A_{ec}(P_{ec} - P_a)$ — For turbofan & propfan
- η_p (propulsive eff.) $= \frac{uT}{uT + 0.5\dot{m}_e(U_e - u)^2} = \frac{u\{\dot{m}_a[(1+f)U_e - u] + A_e(P_e - P_a)\}}{u\{\dot{m}_a[(1+f)U_e - u] + A_e(P_e - P_a)\} + (0.5\dot{m}_a(1+f)(U_e - u)^2)}$
- $\eta_p = \frac{2uT}{\dot{m}_a[(1+f)U_e^2 - u^2]}$ → Turbofan & propfan
- $\eta_p = \frac{u(T_h - T_c)}{u(T_h - T_c) + W_h + W_c}$

  Hot thrust $(T_h) = \dot{m}_h[(1+f)U_{eh} - u] + A_{eh}(P_{eh} - P_a)$

  Cold thrust $(T_c) = \dot{m}_c[U_{ec} - u] + A_{ec}(P_{ec} - P_a)$

  wake losses $(W_h) = \frac{1}{2}\dot{m}_h(1+f)(U_{eh} - u)^2 = \frac{1}{2}\dot{m}_{eh}(U_{eh} - u)^2$

  $W_c = \frac{1}{2}\dot{m}_c(U_{ec} - u)^2$
- $\eta_p = \frac{Tu}{Tu + 0.5\{\dot{m}_{eh}(U_{eh} - u)^2 + \dot{m}_c(U_{ec} - u)^2\}}$
- $\eta_p = \frac{2uT}{\dot{m}_h\{(1+f)U_{eh}^2 + \beta U_{ec}^2 - (1+\beta)u^2\}}$; Bypass ratio $(\beta) = \dot{m}_c/\dot{m}_h$
- η_{th} (Thermal eff.) $= \frac{Tu + \frac{1}{2}\dot{m}_a(1+f)(U_e - u)^2}{\dot{m}_f Q_R}$ → Ramjet & Turbojet
- $\eta_{th} = \frac{Tu + \frac{1}{2}\dot{m}_h(1+f)(U_{eh} - u)^2 + \frac{1}{2}\dot{m}_c(U_{ec} - u)^2}{\dot{m}_f Q_R}$ → Turbofan & Propfan
- unchoked condition, $\eta_{th} = \frac{[(1+f)U_e^2 - u^2]}{2fQ_R}$; $\eta_{th} = \frac{U_{eh}^2 + \beta U_{ec}^2 - (1+\beta)u^2}{2fQ_R}$
- η_o (overall eff.) $= \frac{Tu}{\dot{m}_f Q_R}$; unchoked, $\eta_o = \eta_{th}\frac{2u}{u + U_e}$
- Specific Thrust $= T/\dot{m}_a$
- $TSFC = \dot{m}_{fuel}/T = \frac{f}{(T/\dot{m}_a)}$
- Specific Impulse $(I_{sp}) = T/\dot{m}_f g$
- $f = \frac{C_{ph}T_{03} - C_{pc}T_{02}}{\eta_b Q_R - C_{ph}T_{03}}$
- Exhaust velocity $(U_e) = \sqrt{2C_{ph}T_{03}\left[1 - \left(\frac{P_a}{P_{03}}\right)^{\frac{\gamma_h - 1}{\gamma}}\right]}$

} Pulsejet & Ramjet